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THE EFFECT OF CONCENTRATION RATIO OF SUGARCANE BAGASSE AND STARCH FIBER ON THE CHARACTERISTICS OF NATURAL STYROFOAM FOR ENVIRONMENTALLY FRIENDLY FOOD PACKAGING RAW MATERIALS

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ABSTRACT

Styrofoam is one type of food packaging that we often find. Styrofoam has excellent heat and cold resistance so it is used as an insulator. The ability to withstand good temperatures, lightweight and practical encourages the use of styrofoam as a food and beverage packaging material. However, Styrofoam contains many harmful substances and is not environmentally friendly. One solution is to replace the material for making styrofoam which is environmentally friendly called biodegradable foam. Sugarcane bagasse fiber has the potential as a basic material for making biodegradable foam. The purpose of this experiment is to determine the effect of the addition of bagasse fiber on the characteristics of biodegradable foam. This experiment uses a complete randomized design method with sugarcane bagasse fiber concentration treatment. The characteristic tests carried out include tensile strength test, water absorption test, biodegradation test, and thermogravimetric analysis. From the results of bagasse fiber decomposed 9,130 mg and still remaining 1,13 mg. The optimum concentration of biodegradable foam bagasse fiber on water absorption, biodegradation rate, and tensile strength in the 90:10 composition sample. The results of functional group analysis showed O-H and C-O groups which indicated that biodegradable foam is easily degraded by microorganisms in the soil.

Keywords: *Biodegradable foam, bagasse, cassava starch, packaging.*

Introduction

Styrofoam is one type of food packaging that we often find [1]. Styrofoam has excellent heat and cold resistance so it is used as an insulator. The ability to withstand good temperatures, lightness and practicality encourages the use of styrofoam as a food and beverage packaging material [2]. In general, styrofoam packaging is only used once, then it is thrown away, often causing a lot of piles of waste because styrofoam cannot be degraded.

Styrofoam contains 95% air so it is very light and 5% styrene which is dangerous to be used as a food container. Styrene is soluble in fat, heat, alcohol/acetone, vitamin A (toluene) and milk. Styrene is a chemical that is toxic or neurotoxic which can attack the nerves and cause damage to the nerves of the brain in humans [3][4]. Several institutions such as the WHO (World Health Organization) and EPA (Environmental Protection Agency) have declared styrofoam a carcinogen, because the benzene used to manufacture styrene cannot be digested by the digestive system and cannot be excreted/excreted through urine or feces. The more styrene that accumulates in the body will be wrapped in fat, which will trigger the emergence of cancer cells.

Styrofoam is proven to be not environmentally friendly, because it cannot be decomposed at all. Even the production process itself produces a lot of waste, so it is categorized as the largest waste producer in the world by the EPA (Environmental Protection Agency) [5][6].

Based on this, another alternative is made to produce food packaging, one of the efforts that can be made to reduce the use of Styrofoam is to make biodegradable foam made from cassava starch with the addition of bagasse as a filler.

Bagasse is waste from sugarcane plants that have been milled for the sugar-making process [7]. Bagasse itself is one of the potential natural fibers with an abundant amount, which is about 30% of the weight of the sugarcane plant [8]. While the content contained in cassava starch is 36.7% carbohydrates, 4.2% protein and 0.1% fat. Starch can be used in the manufacture of biodegradable foam because it is inexpensive, highly biodegradable, non-toxic and widely available in nature. But the biodegradable foam formed from starch can dissolve in water and has poor physical and mechanical properties [9]. Because the carbohydrate content in cassava starch is relatively low, additives are added to improve its quality [10].

Based on the above background, the purpose of this research is to make biodegradable foam using cassava starch, because it is cheap, low density, low toxicity and easy to decompose, chitosan additives are added with the aim of improving the mechanical properties of the biodegradable foam obtained.

RESEARCH METHODOLOGY

Materials and tools

The materials used in this study were as follows: cassava starch, bagasse fiber, magnesium stearate, chitosan, glycerol, polyvinyl alcohol and water solvent. The tools used in this study were as follows: mixer, beaker glass spatula, hot plate, thermometer, measuring pipette, ball pipette.

1) Manufacture of starch and bagasse fiber raw materials

Cassava starch is obtained from cassava raw materials obtained from traditional markets. Cassava is grated to a pulp and then squeezed or extracted. After the squeeze process then deposited for 24 hours. Then separated the water and starch. The wet cassava starch is then dried in the oven for 5 hours. Dried cassava starch is mashed using a blender to become cassava flour.

Meanwhile, bagasse fiber is obtained from the remaining sugarcane juice milling waste. The bagasse obtained is first soaked for one day and then washed thoroughly to remove the sweet taste from the fiber. Then comb it with a wire brush to remove the cork that sticks with the fibers. Bagasse that is free from the sweet taste and cork attached to it is dried in the oven for a few hours or so. The dried bagasse fiber is then milled or crushed and sieved using a 100 mesh sieve.

2) Making Biodegradablefoam

Making biodegradable foam begins with dissolving a certain weight of starch in 500 ml of distilled water. The starch solution was heated using a hot plate at a heating temperature of 105ºC and stirring was carried out with variations in time. After that, 4 ml of glycerol (pa) plasticizer was added, then PVA solution and magnesium stearate were added to the starch solution and stirred until evenly distributed. After the mixture is mixed, add bagasse fiber with certain variations while stirring until it forms a gel mixture, after the heating time is over, the hot plate is turned off.

Then the mixture in the form of dough is poured into the print media. The printed dough is then dried in an oven at 45ºC to form biodegradable foam. After drying, the biodegradable foam is removed from the mold and is ready to be analyzed or tested for the characteristics of the biodegradable foam obtained.

3) Characteristics Analysis

a. Tensile Strength

The mechanical properties of biodegradable foam can be seen by conducting a tensile test. Tensile strength or tensile strength is the breaking strength of a material which is calculated from the division of the maximum force that the material can bear against its initial cross-sectional area. The purpose of conducting a tensile test is to determine the tensile strength of biodegradable foam.

The nature of thermoplastic polymers generally has two phases, namely the amorphous phase and the crystalline phase. The crystalline region is composed of regular and tightly packed molecular chains so that it has a greater tensile strength than the amorphous region. While the amorphous region has a disordered molecular chain.

b. Thermal Gravimetry Analysis

TGA is a technique for measuring changes in the amount and rate of weight of material as a function of temperature or time in a controlled atmosphere. Measurements are used to determine material composition and predict its thermal stability at temperatures up to 1000˚C. This technique can characterize materials that exhibit weight loss or gain due to decomposition, oxidation or dehydration. The thermal properties of a material describe the behavior of the material when subjected to thermal treatment (heated or cooled). Thus knowledge of the thermal properties of a material into goods is very important in relation to the processing of materials into finished goods as well as for quality control.

c. Fourier Transform Infrared

FTIR spectrophotometer is an infrared spectroscopy method. Infrared (IR) spectroscopy can identify the content of complex groups in compounds, but cannot determine the molecular constituent elements. In IR spectroscopy, IR radiation is passed through the sample, some of the IR radiation is absorbed by the sample and some is passed on. If the frequency of a specific vibration of a particle is equal to the frequency of IR radiation directed at the molecule, the molecule will absorb the radiation. The resulting spectrum depicts molecular absorption and transmission, forming a sample's molecular fingerprint.

RESULT DAN DISCUSSION

In this study, biofoam was made using the extrusion method, which is a method of mixing two or more ingredients together by utilizing starch which can expand due to heat and friction during the extrusion process. The basic ingredients in this study were cassava starch with bagasse fiber used in various concentrations (50:50 ; 60:40 ; 70:30 ; 80:20 ; 90:10 gr). Biofoam made from starch is generally brittle and stiff, so it is necessary to add glycerol to increase the flexibility of the polymer material which is a plasticizer. Glycerol is a hydrophilic plasticizer, making it suitable for hydrophilic biofoam forming materials such as starch [11]. However, biofoam that uses glycerol still has deficiencies in the characteristics of biofoam.

From this study the results obtained in the form of observational data, analysis and data processing can be seen from the results of measurements of the physical characteristics of biodegradable foam such as tensile strength test, water absorption test and biodegradation level. The research results can be seen in Table 1.

TABLE I
RESULTS OF SEVERAL CHARACTERISTIC TESTS OF BIODEGRADABLEFOAM

Starch Composition : Fiber	Test result			
	Time (minutes)	Tensile Strength (M.Pa)	Water absorption	Biodegradation (%)
50:50 (A1)	30	1.09	13.36	15.83
	45	1.38	11.60	22.68
	60	3,29	54,31	41.88
60:40 (A2)	30	2.04	30,53	20.45
	45	1.75	36,61	19.99
	60	2.56	30,84	14.78
70:30 (A3)	30	0.50	22.95	61,66
	45	1.00	26.80	18.55
	60	3.05	35,86	24,21
80:20 (A4)	30	0.37	43,33	36,66
	45	3.86	39.78	34.78
	60	5,14	49,27	32,29
90:10 (A5)	30	4.69	6,25	25.00
	45	4.99	8.95	19.35
	60	5,48	2.00	21.77

Tensile Strength Test Results

The mechanical properties of biodegradable foam can be seen by conducting a tensile test. Tensile Strength or tensile strength is the breaking strength of a material which is calculated from the distribution of the maximum force that the material can bear against the cross-sectional area of the material initially. The purpose of carrying out a tensile test is to determine the tensile strength of biodegradable foam. The mechanical properties of biodegradable foam can be seen by conducting a tensile test.

From Figure 1 it can be seen that the highest tensile strength of biodegradable foam was obtained, namely 5.48 MPa in sample A5 with a time of 60 minutes, while the lowest tensile strength value was 0.37 MPa in sample A4 with a time of 30 minutes. The average value of the tensile strength of biodegradable foam shows that the more the concentration of bagasse fiber is added, the tensile strength value will decrease. The decrease in tensile strength results is strongly suspected due to the lack of sorption or the amount of starch as a filler or fiber binder. This is also the same as researchers who have done by other researchers [14]. Figure 1. Graph of comparison between time versus tensile strength (Mpa) on biodegradablefoam bagasse fiber.

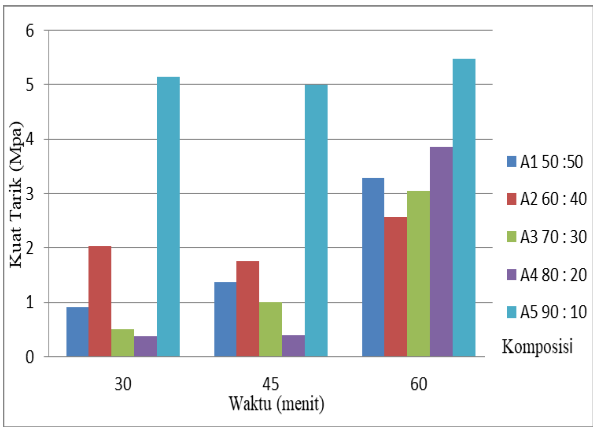

Figure 1. Graph of the effect of fiber on tensile strength

Tensile strength is also affected by the addition of bagasse fiber. The more bagasse fiber added, the less tensile strength of the biodegradable foam. Conversely, the less bagasse fiber added, the better. Glycerol functions to increase the elasticity of biodegradable foam due to the function of glycerol as a plasticizer [12]. The standard tensile strength of biodegradable foam is 29.16 MPa based on the Indonesian national standard (SNI). In this study, the tensile strength values for all concentrations were not included in the Indonesian National Standard (SNI).

Water Absorption Results

Water absorption is the amount of water absorbed by biodegradable foam after being immersed in water. Water absorption was determined by weighing the sample before and after being immersed in water with a variation of 1 minute in three repetitions. The concentration of corn bagasse fiber added to the biodegradable foam is inversely proportional to the water absorption capacity, that is, the more the concentration of bagasse fiber added to the biodegradable foam, the less water absorption it has. The average value of water absorption can be seen in Figure 2.

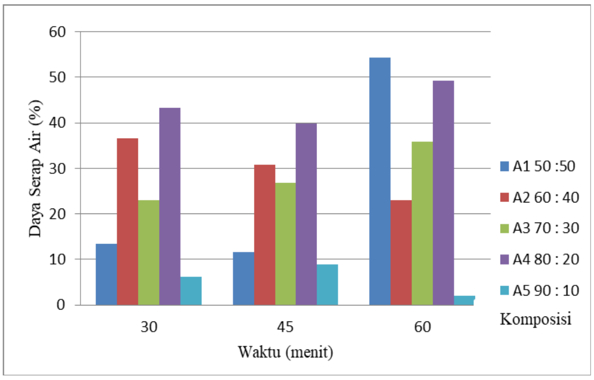

Figure 2. Graph of the effect of fiber on water absorption

From Figure 3 the results of the water absorption test on biodegradable foam with the five types of different concentrations show different decreases and increases. In sample A1 with a time of 60 minutes the water absorption capacity is 54.31%. In sample A4 with a time of 60 minutes the increase in water absorption began to increase, namely 49.27%. In this sample there was an increase due to the inhomogeneous mixture of materials causing cavities to occur. While the lowest water absorption occurred in sample A5 with a time of 60 minutes, namely 2%. The results of this study are not in line with the research conducted by Hendrawati [13], namely the more chitosan is added, the absorption capacity of biodegradable foam on water decreases. This happens because the limit of adding chitosan has been optimum and no further reactions will occur.

The fiber content of bagasse from the five samples used affects the water absorption capacity of a biodegradable foam. Because the higher the fiber composition of bagasse, the higher the water absorption. The standard for water absorption of biodegradable foam is 26.12% based on the Indonesian National Standard (SNI). In this study, not all concentrations with 1 minute soaking time were included in the standard (SNI).

Biodegradation Test Results

A biodegradation test method is needed to determine the natural biodegradability of biodegradable foam. In the research that has been done, it was obtained biodegradability test data for biodegradable foam products at various process time and temperature variations. The method is done by burying the sample into the ground. Biodegeadablefoam burial was carried out with the aim of seeing the ability of biodegeadablefoam to degrade in the soil. The factors that can affect biodegradation are chemical factors such as (Ph, temperature, moisture content, nutrient availability, redox potential, presence of inhibitors). And ecosystem microbiological factors such as (microbial activity, microbial diversity, and spatial distribution of microorganisms), as well as the properties of polymer materials and the process of making materials. The degradation test was carried out for 7 days.

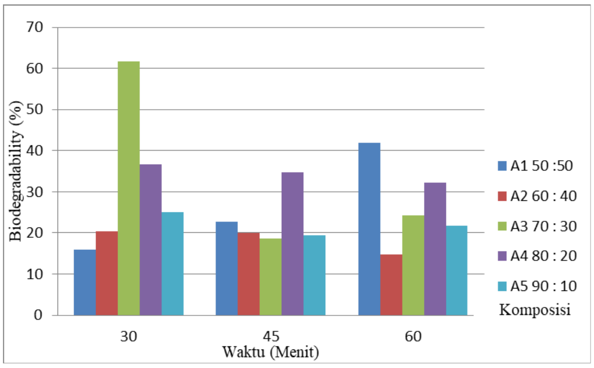

Figure 3. Graph of the effect of fiber on biodegradation

Figure 3. Comparison graph between time versus biodegradation (%) in Biodegradablefoam bagasse fiber. From figure 3 the results of the biodegradation test on biodegradablefoam show different decomposition abilities. The biodegradability of the resulting biodegradable foam product had the highest value in sample A3 with a time of 30 minutes, namely 61.66% and the lowest in sample A2 with a time of 60 minutes, namely 14.78%. This is because in the biodegradation testing process there is the addition of EM4 fertilizer so that the micro-mix culture consisting of Lactobacillus, Actinomyces, Streptomyces bacteria, fungal

yeasts and photogenic bacteria work together to support each other (simultaneously) in decomposing organic matter. The same thing was done by research that had been carried out by other researchers [14] who also used EM4 to show the same thing.

Results of Thermogravimetric Analysis (TGA) Analysis

Thermogravimetric Analysis (TGA) was performed to determine the thermal resistance of biodegradable foam when heated from 40ºC to 600ºC. Thermogravimetric Analysis (TGA) changes in sample weight during the analysis process. This is because the sample will burn when it reaches a certain temperature. The process of losing mass in the sample occurs due to the decomposition process, namely the process of breaking chemical bonds.

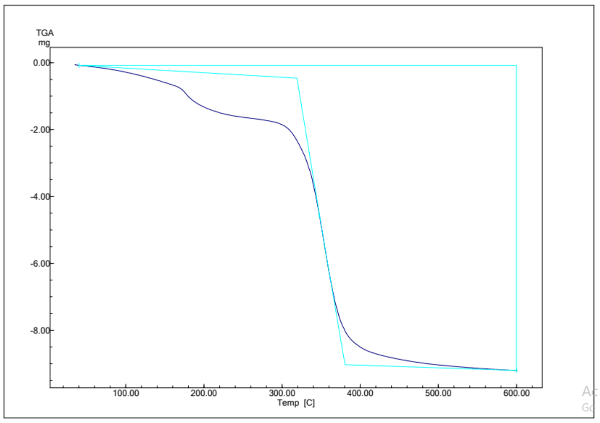

Figure 4. Graph of thermogravimetric test results (TGA)biodegradablefoam bagasse

Figure 4 Graph of thermogravimetric analysis (TGA) on biodegradable foam made from starch with bagasse fiber. Figure 4. Graph of the results of thermogravimetric analysis (TGA) on biodegradable foam of bagasse fiber at 387.86 ºC decomposes 9,130 mg and 1.13 mg remains. TGA thermogram changes occur due to changes in biodegradablefoam heat but also due to structural changes and phase changes of the biodegradablefoam. So it can be concluded that the higher the weight of the decomposed residue, the better the thermal resistance of the biodegradable foam.

Functional Group Analysis Results

Fourier Transform Infrared (FT-IR) analysis is used to determine the functional groups formed from the resulting sample and also to predict the polymerization reactions that occur. This analysis dis based on the analysis of the characteristic peak wavelengths of a sample. The wavelengths of these peaks indicate the presence of certain functional groups present in the sample, because each functional group has a specific characteristic peak for that functional group.

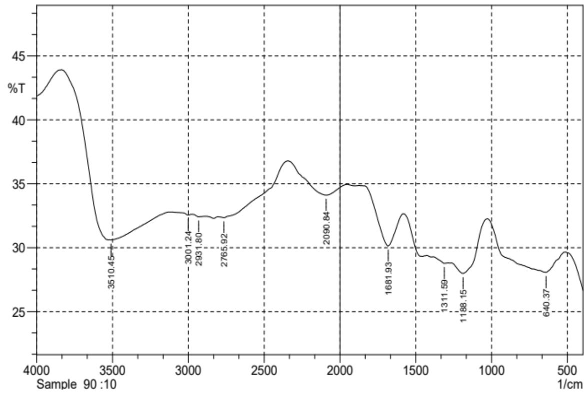

Figure 5. Graph of the results of the Fourier Transform Infrared (FT-IR) analysis of biodegradable bagasse foam

Analysis using FT-IR instrumentation was carried out to determine the functional groups and bonds contained in biodegradable bagasse foam with the best tensile strength values. From graph 5 it can be seen that the spectrum results obtained for an absorption of 3510.54 cm-1 in the biodegradable foam sample which shows an absorption area of 3000 cm-1– 4000 cm-1 is a typical area of the O-H group. The presence of the OH group comes from the components of the starch composition, namely amylose and amylopectin. In addition, a spectrum of 1311.59 cm-1 appears which indicates an absorption area of 1000 cm^{-1}–1400 cm^{-1} which is a typical area of the C-N functional group and a spectrum of 1188.15 cm^{-1} which indicates an absorption area of 100 cm^{-1}–1400cm^{-1} is a typical area of the functional group C-O.

CONCLUSION

Conclusion Based on the research results obtained, namely that bagasse fiber has the potential to be developed as a raw material for making biodegradable foam and has a significant influence on the strength of biodegradable foam. The more the amount of bagasse fiber in the composition of a biodegradable foam, the lower the tensile strength will be. The lowest biodegradable

foam tensile strength was in sample A4 in 30 minutes with a value of 0.37 MPa and the highest in sample A5 in 60 minutes with a value of 5.48 MPa. The lowest water absorption test results were in sample A5 at 60 minutes, namely 2% and the highest in sample A1, namely 54.31%. The lowest biodegradability test results were in sample A1 in 30 minutes, namely 15.83% and the highest in sample A3 in 30 minutes, namely 61.66%.

BIBLIOGRAPHY

[1] Sulchan M and Endang NW. "Food Safety of Plastic and Styrofoam Packaging". Indonesian Medical Magazine 57, no. 2 (2007): h. 54-59.

[2] Khairunnisa, S. (2016). Styrofoam Waste Processing into Fashion Products. E-Proceedings of Art and Design, 3(2), 253-268

[3] Daulay. "Variation of Phenol Formaldehyde Styrofoam Phenol Size and Adhesive Composition on the Quality of Particle Board from Palm Oil Stem Waste". Thesis, Sumatra: Faculty of Agriculture, North Sumatra, 2014.

[4] Trisia A. Farrelly and Ian C. Shaw (2017) Polystyrene as Hazardous Household Waste.http://dx.doi.org/10.5772/65865.

[5] Wicaksono, Bagas. "Processing Styrofoam Waste, Orange Peel and Sanseveiria Fiber into Synthetic Yarns with Economic Value". Thesis, Bogor: Faculty of Agricultural Technology, Bogor Agricultural University, 2011.

[6] US Environmental Protection Agency (US-EPA), 1970.

[7] Rokhman, H., Taryono, & Supriyanta. (2014). Number of tillers and yield of six clones of sugarcane (Saccharum officinarum L.) from mule seeds, single eye nodes and single buds. Vegetarianism, 3(3): 89-96.

[8] Purnawan, C., Hilmiyana, D., Wantini., & Fatmawati, E. (2012). Utilization of Bagasse Waste for Decorative Paper Making Using the Organosolv Method. Journal of Ecoscience, 4(2): 1-6.

[9] Fang, Q., and Hanna, M., (2015), Preparation and characterization of biodegradable copolyester–starch based foams. Bioresource Technology, 78 (2):155-122..

[10] Inggaweni, L. (2015). Characterization of mechanical properties of biodegradable plastic from high density polyethylene (HDPE) and cassava peel starch composites. In the National Chemistry Seminar. Surabaya, Indonesia: State University of Surabaya.

[11] Foam, B., & Process, B. (2015). Journal of Renewable Natural Materials Effect of Addition of Magnesium Stearate and Type of Protein in Making Biofoam from Cassava Starch. 4(9), 34–39. https://doi.org/10.15294/jbat.v4i2.4166

[12] Algado, PR, Schimdt, VC, Sara, E., (2008), Biodegradable Foam Based On Cassava Starch, Sun Flower Proteins, and Cellulose Fibers by a Baking Process. Journal of Food Engineering 85. 435-443.

[13] Hendrawati, N., Dewi, EN, Santosa, S., Chemistry, JT, Malang, PN, & No, JS (2019). Characterization of Biodegradable Foam from Modified Sago Starch with Chitosan as an Additive. 3(9), 47–52.

[14] Derived, BF, Friendly, E., & Packaging, F. (2018). Biodegradable Foam from Banana Weevils and Nagarat Sweet Potatoes as Environmentally Friendly Food Packaging. 33–42.